



## ***GIS Approach to Measure Accurate Spatial Distribution of Aviation Noise and Affected Populations***

**Simon Choi, Ping Wang, Ying Zhou  
Southern California Association of Governments  
&  
SungHo Ryu  
University of Southern California**

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## ***Presentation Outline***

- Objective / Keywords
- Background
- Purposes of the Study
- Data & Methods
  
- GIS Applications and Model Results
- Grid Cell Method: Findings and Challenges
- Conclusion





## *Objective of the Study*

Comparing  
**Two Geographic Level Forecasts**  
for the Analysis of  
**Environmental Justice** in 2035.



## *Two Geographic Level Forecasts*

- 2,243 (obs.): **Transportation Analysis Zones**  
(TAZ) level in LA County
- 276,393 (obs.) **Grid Cells** (5.5 Acre)  
in LA County





## ***What is Environmental Justice (EJ)?***

“The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies.”

-US Environmental Protection Agency

- **Environmental Justice (EJ) analysis**  
Socio-economic variables (secondary var.)



## ***Socio-economic Variables***

- **Socio-economic Variables**
  - Ethnicity
  - Minority (Hispanic, Asian & Pacific Islanders, African Americans, Native Americans, Others)
  - Non-Hispanic White
  - Ages & Elderly (Over 65)
  - Gender
  - Disabled
  - Household Income
  - Households by Poverty Level



## ***EJ Policy/Procedure Documents***

- Title VI of the Civil Rights Act of 1964
- President Clinton's Executive Order 12898 (1994)
- CEQ Environmental Justice Guidance Under the National Environmental Policy Act (1997)
- US Department of Transportation (DOT) Order (1997)
- Federal Highway Administration Order (1998)
- FHWA/FTA Memorandum: Implementing Title VI Requirements in Metropolitan and Statewide Planning (1999)

## ***SCAG Region***





## *What is SCAG's Role for EJ?*

- Designated as MPO
- Must comply with legal requirements
- Goal: Ensure that the Regional Transportation Plan's (RTP) benefits and burdens are distributed equitably



## *EJ Framework*

- The core questions are:
  - Are people worse or better off with or without the Plan?
  - Is there a disproportionate negative impact of the Plan on any group?





## ***EJ Analysis Methodology***

- Performance Indicators?
  - Quantitative measurements used to assess the impact of the Plan
  - Accessibility
  - Congestion (time savings)
  - Travel Distance Reductions
  - **Aviation Noise**
  - Highway Noise
  - Air Pollution



## ***Past Findings and Implications***

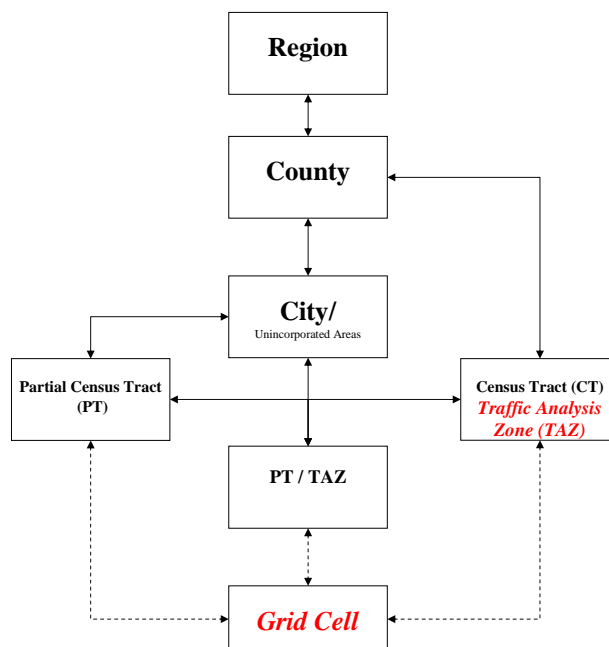
- 2001/2004/2008 RTP EJ Analysis Findings
  - Low income and minority groups will be disproportionately impacted by aviation noise.
- Implications
  - Limiting growth at LAX is positive for EJ
  - Influenced regional policy makers to pursue a distributed regional aviation policy to minimize aviation impacts.



## *Purposes of the Study*

- EJ analysis is traditionally based on the TAZ level estimates and forecasts.
  - Can we develop reasonable grid cell level socioeconomic forecasts for the noise impact area of LAX?
  - Does the grid cell level forecast produce more accurate socioeconomic data than the TAZ level forecast?
  - What are the challenges and lessons learned from the grid cell level forecast application?

### *TAZ and Grid Cell*





## ***TAZ level Forecast & EJ Analysis***

1. Major variables at TAZ level: ***trend/negotiated forecasts*** (County Controlled)
2. Secondary variables at TAZ level: ***Discrete Choice Model*** (County Controlled)
3. Develop the noise impact contour (65 dB CNEL) using the Integrated Noise Model (INM)
4. Assign the 2035 forecasts to noise impact areas using GIS interpolation technique (area interpolation)
5. Aggregate the assigned forecasts within airport noise contour.
6. Generate the tables.



## ***Grid Cell Level Forecast & EJ Analysis***

1. Major variables at TAZ level: ***trend/negotiated forecasts***
2. Secondary variables at TAZ level: ***Discrete Choice Model***
3. Develop the noise impact contour (65 dB CNEL) using the Integrated Noise Model (INM)
4. Generate grid cell (150 x 150 meter) using Spatial Analyst extension.





## ***Grid Cell Level Forecast & Analysis***

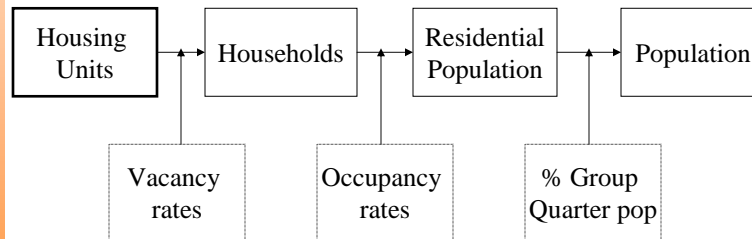
5. Assign the 2035 forecasts to each grid cell
  - 1) Major variables at grid cell level: land use forecast model (I-Place<sup>3</sup>S)
  - 2) Secondary variables at grid cell level: MNL regression methods (MNL regression coefficients are derived from SASVAM for TAZ level)
6. Aggregate the grid cell forecasts within airport noise contour.
7. Generate the tables

## ***Grid Cell Level Forecast: Major Variables Development***

- Grid cell level housing unit forecast is derived as part of regional growth visioning/forecast efforts. Existing land use, general plan, environmentally sensitive areas, local planners' input, etc are factored in the forecast process.

## ***Grid Cell Level Forecast: Major Variables Development***

- Housing Unit Method



## ***Secondary Variables Forecasting: (SASVAM)***

- Small Area Secondary Variables Allocation Model (SASVAM)
- Secondary variables are any variables other than major variables (population, households, employment).
- Major variables become input data for SASVAM

## ***Secondary Variables***

- Population
  - by Age
  - by Race/Ethnicity
  - by Sex
- Household
  - by Age
  - by Race/Ethnicity
  - by Poverty
  - by Income
- Employment (jobs)
  - by Sector
  - by income level
- by # of persons
- by # of workers

## ***SASVAM: Multi-nomial Logit Regression***

- Estimate distribution probability of each secondary variable with *Multi-nomial Logit Regression* (*Represent historical relationship, 1990-2000*)
- Multiple categorical dependent variables

$$\text{Pr } ob(y = j) = \frac{\sum_{k=1}^k \beta_{jk} x_k}{1 + \sum_{j=1}^{J-1} e^{\sum_{k=1}^k \beta_{jk} x_k}}$$

## SASVAM: Discrete Choice Model

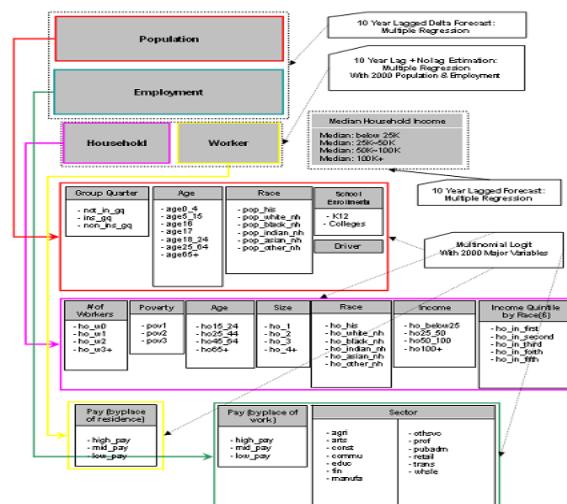
- Population by Race/Ethnicity

Ethnic Categories(2000) = Hispanic pop(1990) +  
NH White(1990)+  
NH Black(1990)+  
NH Indian(1990)+  
NH Asian(1990)+  
NH Other(1990)+  
Age 25-64(1990)+  
Median HH income(1990)+  
Pop density(1990)

Pseudo R-Square : 0.9967

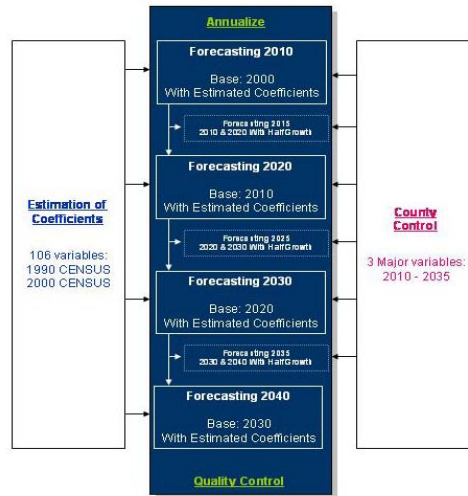
## SASVAM: Variables Groups

### Process of Coefficients Estimation



## SASVAM: Process

### Forecasting Process



## SASVAM: Strengths

- Represent historical temporal trend (1990-2000): Coefficient Estimation
- Constrained by higher level of geography: County Control (TAZ level) or TAZ Control (Grid cell level)
- Consistency between major variables and secondary variables (Example: QC I) **Go**
- Consistency among secondary variables: Quality Control (Example: QC II) **Go**
- Temporal consistency: Annualized data

Next

## ***SASVAM: QC-I***

- Relationship between major variables and secondary variables
  - If Pop=0 then All pop related Var.=0
  - Residential pop (not in GQ) > Worker
  - Residential pop (not in GQ) > Household
  - If Residential pop=0 then HH=0
  - Age\_16+ > Worker

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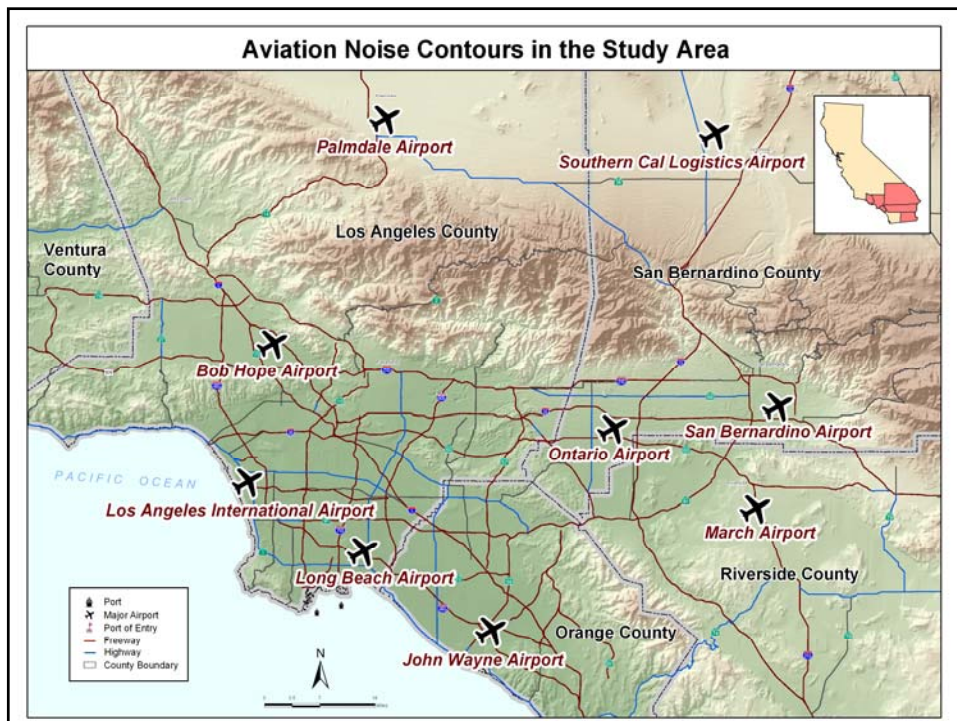
## ***SASVAM: QC-II***

- Relationship among secondary variables  
HH by # person vs. HH by # worker  
HH(10): H\_1(3), H\_2(4), H\_3(2), H\_4\_over(1)  
HH(10): Hw0(2), Hw1(4), Hw2(4), Hw3+(4)

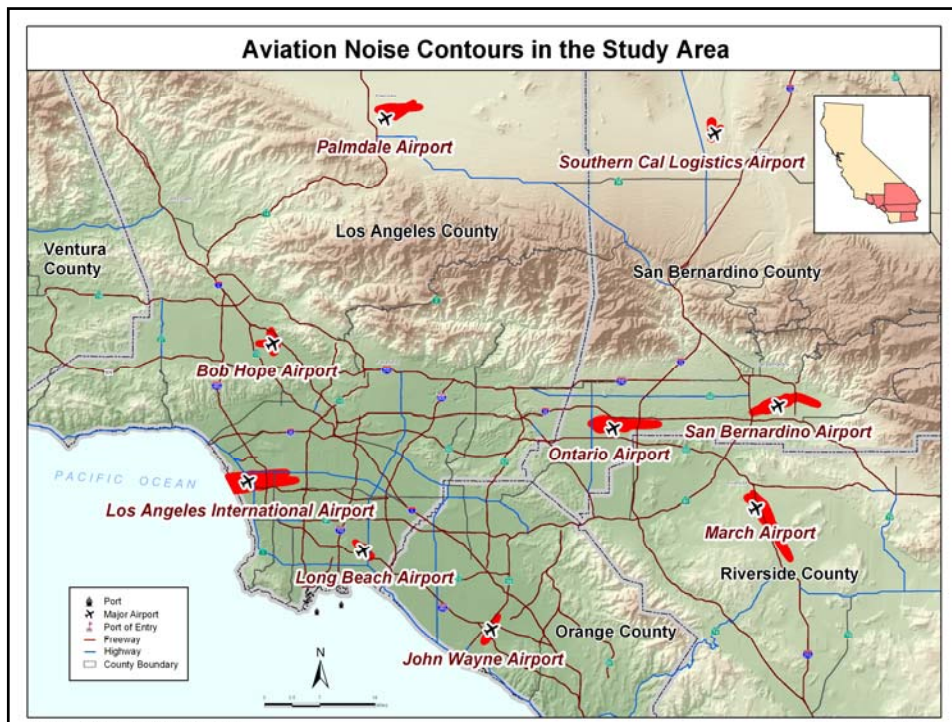
$$H_{w3+(4)} < H_3(2) + H_{4\_over(1)}$$


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## *GIS Applications & Model Results*










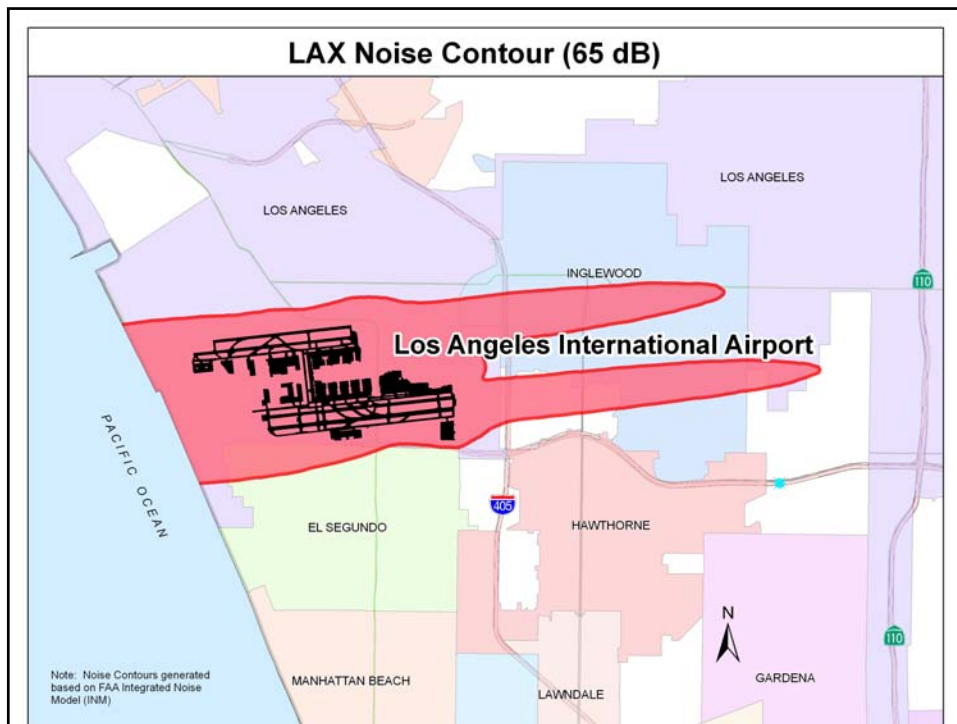
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## *Study Area: LAX*


- At 3,500 acres, LAX is a very small international airport
- LAX is the fifth busiest airport worldwide in terms of passengers and seventh worldwide in air cargo tonnage
- LAX is served by approximately 80 passenger airlines, 20 cargo airlines and contributes more than \$61 billion annually to the Southern California economy.
- LAX handles 70% of the passengers, 75% of the air cargo, and 95% of the international passengers and cargo traffic in the SCAG region.
- Approximately 408,000 jobs or one in twenty jobs are attributed to LAX operations in Southern California.
- LAX has four runways. In 2007 it serviced 62 million annual passengers (MAP) and its maximum capacity is estimated to be 78.9 MAP





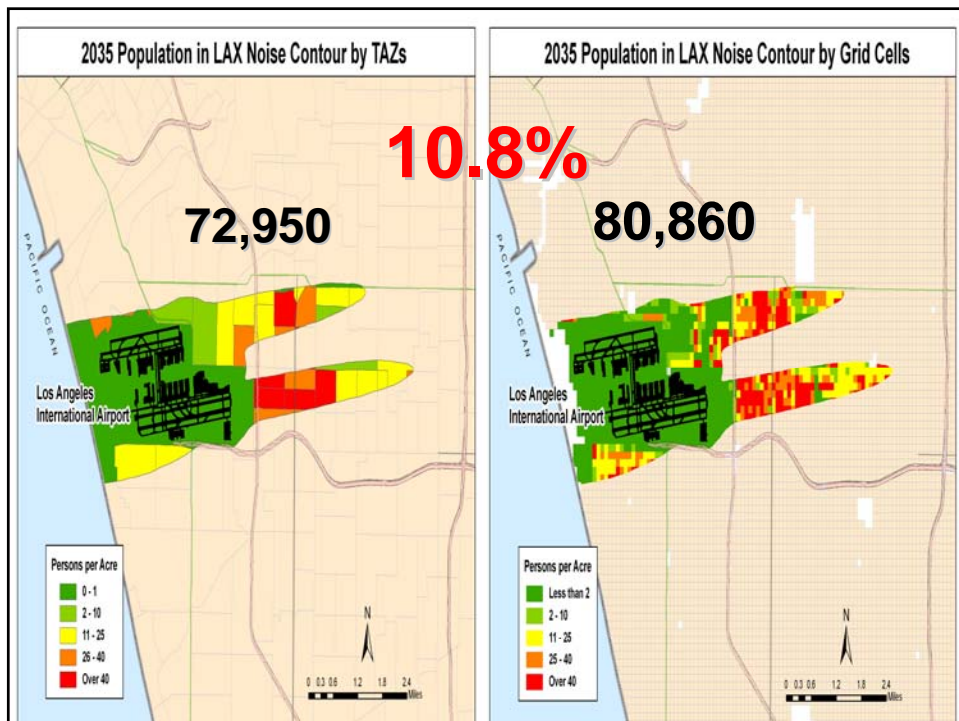
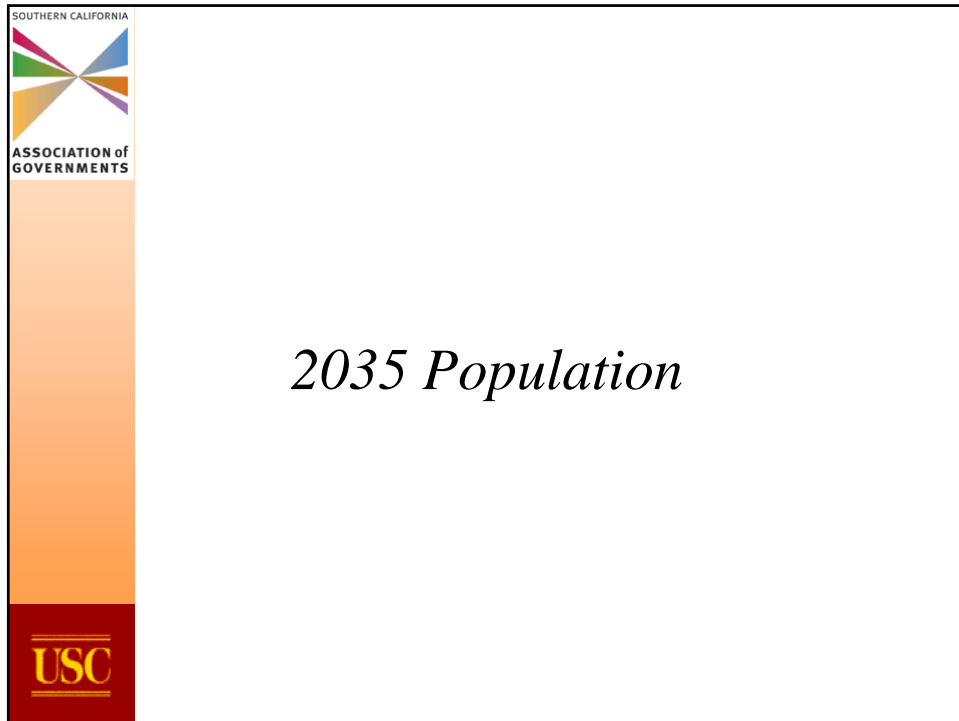


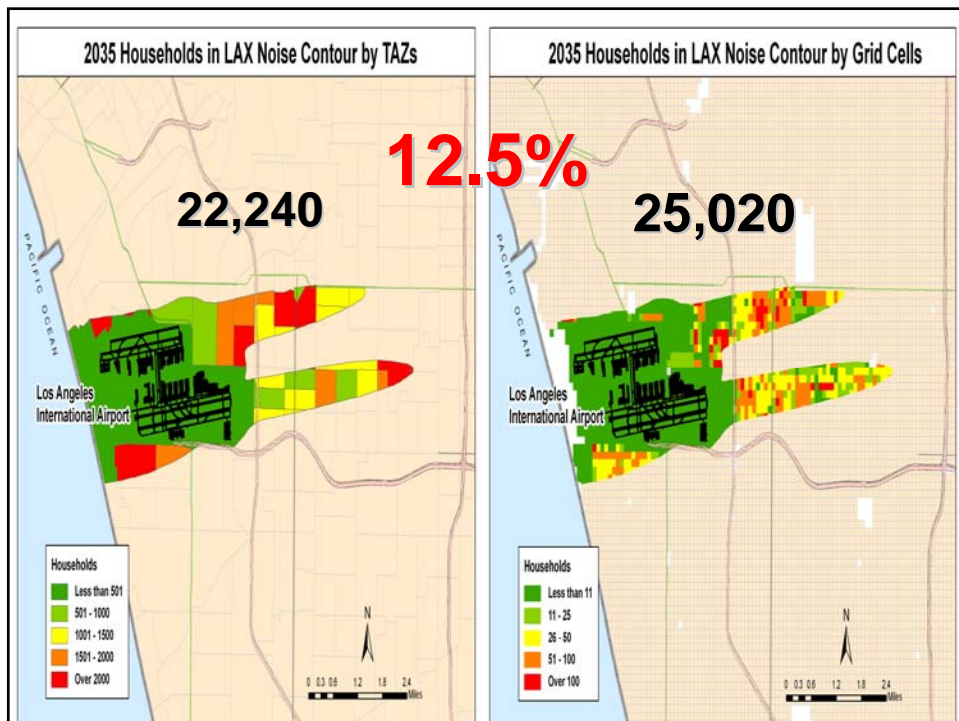
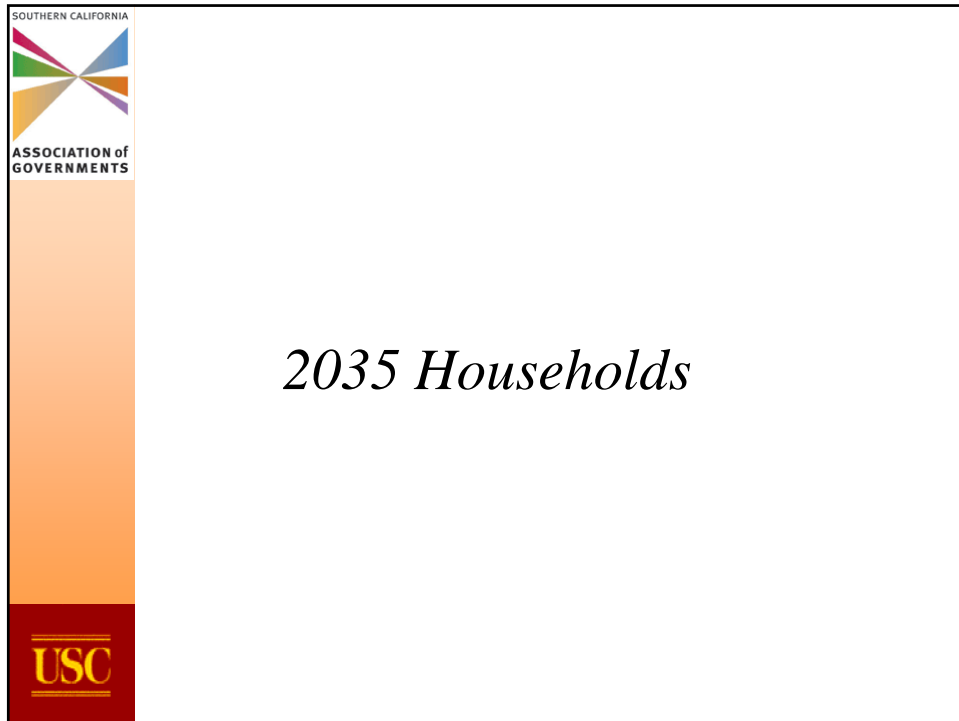
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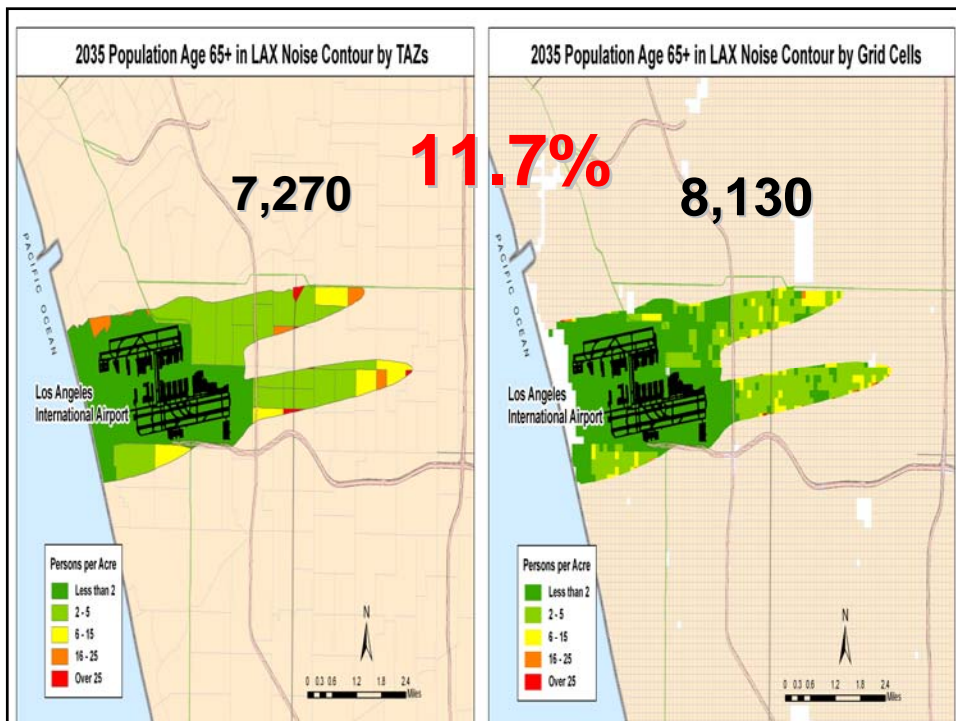
## *Variables*

- Population
  - Age 65 and Over
  - African American
- Households
  - Households Below Poverty
  - Household Income below \$25K in 1999 dollars






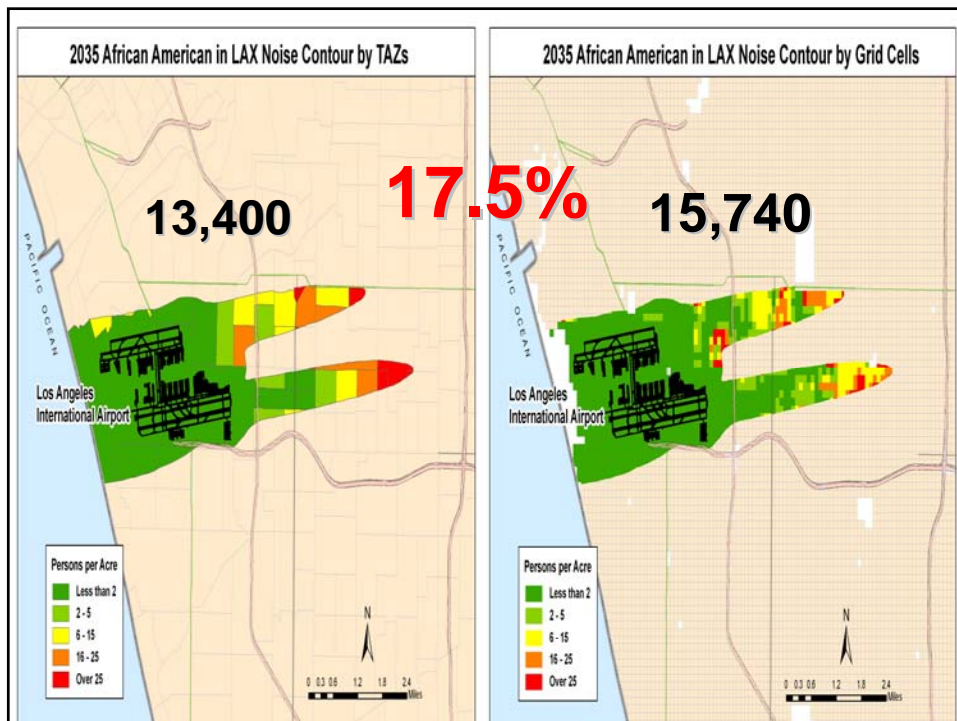
## 2035 Population Age 65+



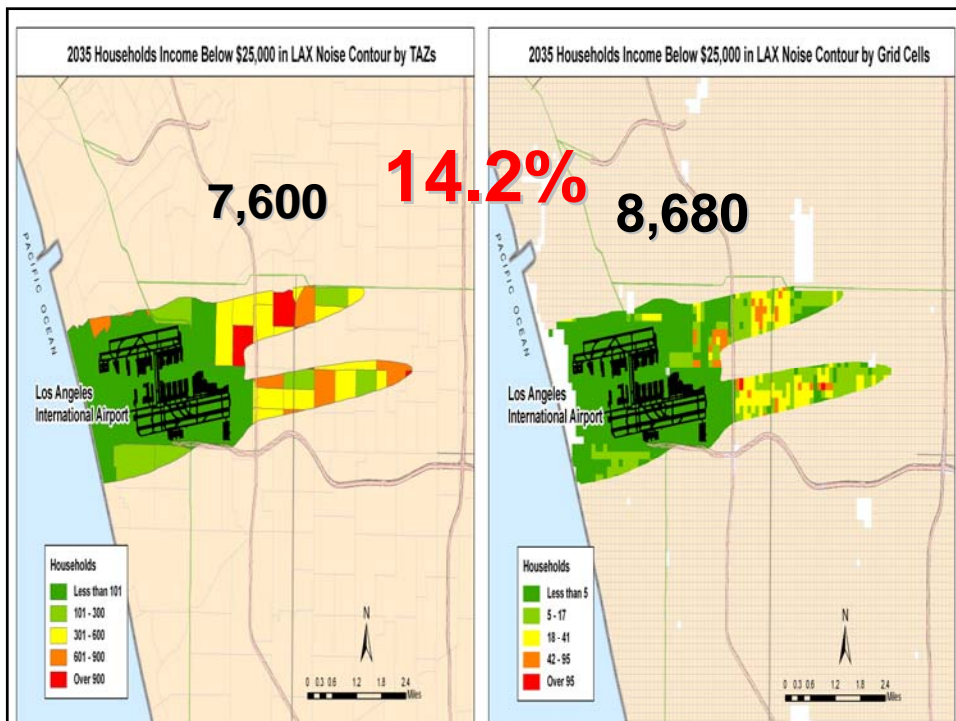
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# 2035 African American

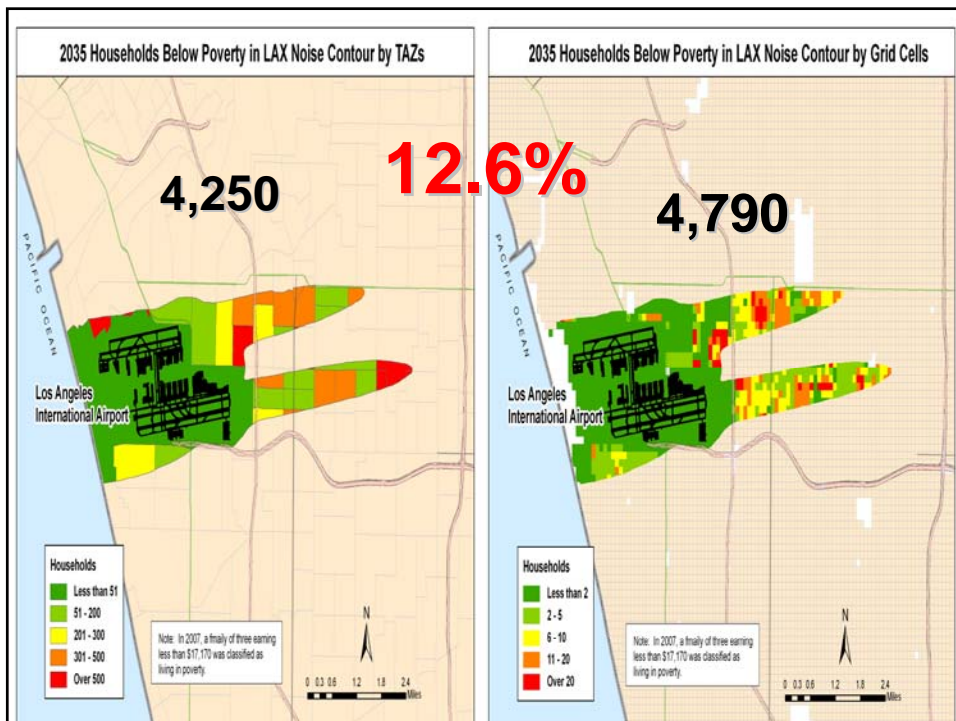


# *2035 Households of Household Income Below \$25,000 (in 1999)*





## *2035 Households Below Poverty*



## *Aviation Noise Impact Results*

2035 Socioeconomic Projections for Noise Impact Area of LAX: TAZ level Method and Grid Cell level Method

	TAZ	Grid Cell	Diff (Raster-TAZ)	% Differ.
Population	72,954	80,860	7,906	10.8%
Age 65 or more	7,270	8,124	854	11.7%
African American	13,397	15,735	2,338	17.5%
Households	22,238	25,015	2,777	12.5%
Households below Poverty	4,248	4,783	535	12.6%
Households below \$25K	7,598	8,676	1,078	14.2%
Number of Observations	36	1,269		

## *Grid Cell Level Forecast Approach: Findings*

- The grid cell level forecast approach is useful and acceptable for small area planning and policy development (e.g., EJ, TOD, Emission Analysis).
- The combined use of GIS and the grid cell forecast model might produce the reasonable socioeconomic “forecasts” for the noise impact area of LAX.
- It seems that the grid cell forecast model produces more accurate socioeconomic forecasts than the “simple” area interpolation technique.
- Complex (land use/general plan weighted) grid cell interpolation might produce accurate socioeconomic forecasts in an efficient way, but might be less politically acceptable due to lack of local input process.





## *Grid Cell Level Forecast Approach: Challenges*

- Importance of major variables (population, household) forecast relative to the secondary variables allocation.
- Group quarter population
- Integer vs. Decimal
  - Calculation
  - Adjustment Process
  - Realistic
- Population (or Households) is 1 or 2(abnormal distribution). How to develop secondary variables?



## *Conclusion*

- Future research
  - Parcel level population projections
  - More integrated forecasting process into GIS models.
  - More interactive spatial analysis with GIS





## *Contact Information*

- Simon Choi: **[choi@scag.ca.gov](mailto:choi@scag.ca.gov)**
- Ping Wang: **[wangp@scag.ca.gov](mailto:wangp@scag.ca.gov)**
- Ying Zhou: **[zhou@scag.ca.gov](mailto:zhou@scag.ca.gov)**
- SungHo Ryu: **[sungryu@usc.edu](mailto:sungryu@usc.edu)**

